DISSOROPHUS COPE

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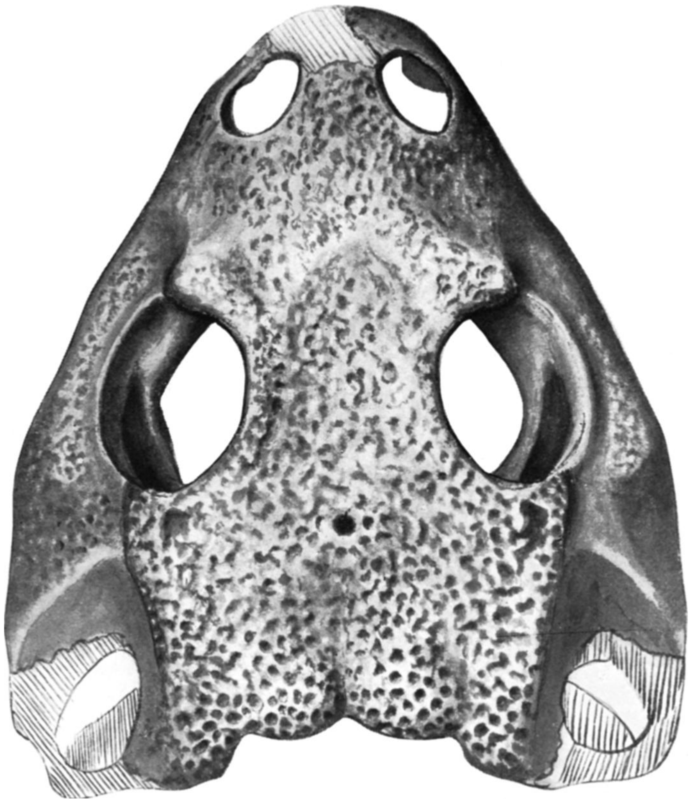
The material herein described and figured was collected by the writer from the upper or Clear Fork Division of the Texas Red-beds on Coffee Creek, in August, 1909. It comprises a nearly complete skull, but little distorted, the two scapulae with attached cleithra, neither complete, but the two supplementing each other nearly perfectly; the two complete clavicles attached to the incomplete interclavicle; the two humeri, one complete save for the capitellar angle, the other with the distal part quite complete and the proximal portion missing; two attached proximal carpals, several vertebrae and fragments of ribs, the nearly complete carapace, a broken and somewhat distorted pelvis, a femur, and fragments of epipodial bones.

For the most part, the surface of the skull is unimpaired, showing deep, almost circular pits, with narrow, reticulating ridges between them. The pittings seem to be most pronounced in the upper posterior part. There are no indications of mucous grooves, and I am convinced that, were they originally present, evidences of them would be apparent. Nor, as in the case of the skulls of *Cacops*, can I distinguish the sutures.

The skull is very broad posteriorly, with a rounded, obtuse muzzle. The orbits are situated about midway in its length, they are rather small, nearly circular in outline, and broadly separated. The table of the cranium, back of the orbits, is rather broader than long, a little wider anteriorly, with a broad emargination behind; it is nearly plane, with its margins elevated. The parietal foramen is situated a little back of a line drawn through the posterior margin of the orbits. Just back of each orbit there is a distinct depression, as in *Cacops*, apparently for the lodgment of some gland. In the middle part behind there is, on each side, a prominent, nearly hemispherical elevation, deeply impressed with large pits; they correspond to the prominent rugosities of the *Cacops* skull, but are much more rounded and less



angular. Behind, these swellings are partly separated by an angular emargination of the hind border. The epiotic region on each side is produced backward considerably beyond the transverse line of the rounded swellings. The broad surface between the orbits is shallowly concave transversely. The thickened upper margin of the orbits is nearly horizontal to the middle of the orbit in front, where there is a rugosity, the outer border of which is nearly vertical. The face in front of the orbits is convex, with a depression on each side in front of the orbital rugosity. The nares are large, oval in outline, and are directed upward and outward and forward. Below and a little behind the orbits there is a distinct elevation or rugosity. The posterior lateral or temporal region is unfortunately wanting on each side, or rather the parts were so mutilated that they could not be joined. The structure here is quite surely as in *Cacops*, the epiotic prolongation with its attached quadrate inclosing the ear opening at the bottom of a cavity. The upper margin of this opening is preserved in part on the left side, as is also most of the smooth bone forming the anterior part of the auditory cavity, the ridge limiting this surface from the roughened exterior of the side of the skull in front of it running downward and backward from a point about ten millimeters back of the orbital margin, to the jugal border.

On the palatal side of the skull the basioccipital, basisphenoid, and parasphenoid could not be recovered, nor the vomerine portion in front. On the left side the pterygoid and palatine regions are nearly perfect and undistorted, save for the interior border of the nares. The nareal opening is long and narrow, the anterior margin a little in advance of the posterior border of the external opening. In front the external border is very close to the dental margin; behind, it is removed a few millimeters. Near the posterior margin of the opening there is a single large tooth, as in *Cacops*, and doubtless there was another on the vomers at the anterior inner border; no other palatine or pterygoid teeth are visible. The infratemporal opening between the pterygoid and jugal margin is shorter and narrower than in *Cacops*, and the lateral process, doubtless corresponding to the transpalatine, is smaller. The basisphenoid process of the pterygoid is stout, transverse, and nearly horizontal. Evidently the structure throughout of the palatal surface was quite alike in the

two genera. Parts only of the walls of the rhinencephalic chamber are preserved.

The maxillary teeth, which extend backward to opposite the beginning of the infratemporal opening, are all very small, and are much more numerous than in *Cacops;* I count about forty-five in each maxilla. Those preserved entire are scarcely more than two millimeters in length.

The mandibles, which, with the exception of the extreme anterior end, are preserved complete, are, like those of *Cacops,* slender bones, deepest immediately in front of the cotylus, with a relatively high coronoid process, which fitted into the infratemporal fossa. I count about thirty-five teeth in each dentary, as preserved. The external surface, at least posteriorly, is closely impressed with circular or oval pits, like those of the cranial table.

Carapace.—The carapace, as preserved, is of essentially the same character as that of *Cacops,* but of a far greater development. In the series, as adjusted, there are indications of twelve or thirteen vertebrae participating in the shield, and others possibly are lost. The whole number may have been the same as in *Cacops aspidephorus,* that is, fifteen, but I suspect there were more. The first dermal shield, covering three or four vertebrae, appears not to have been intimately associated with the spines of the vertebrae. It is very large, not much broader than long, and heavy. Its front border is very obtusely angular in the middle with the borders receding and rounded. The lateral borders are subparallel and gently convex in outline. The posterior border has a gentle emargination in the middle with the lateral sides slightly convex behind. The planes of the sides have an angle of nearly forty-five degrees with each other and are broadly rounded in their union. The dorsal surface is rather deeply pitted, the depressions rounded or oval with reticulating ridges between them. The under surface is smooth, and appears not to have been underlaid with lateral expansions of the spines. Back of this shield, on the under side, there are nine spine dilatations, the first six or seven complete in the specimen. They are thin, flat plates, apparently co-ossified with the rather slender spines above, directed nearly transversely, with a less angle of declivity than has the nuchal or scapular shield. The outer extremities are narrowed or obtusely pointed, their upper

surface beveled both in front and behind for the dorsal shields. Their surface is smooth throughout.

The dorsal shields are rather stout, elongate bones, rounded on their outer extremities, pitted on their dorsal surface like the nuchal shield, forming a rather uniform arc of a circle, with less steepness on the sides than that of the nuchal shield. These shields, thick in their middle line, thinned along their anterior and posterior margins, leave a space of from two to four millimeters between their adjacent borders, in which the smooth surface of the spinal expansions is visible.

Vertebrae.—Not many of the vertebrae are preserved, and such as are, are not in the best condition. They do not seem to differ from the vertebrae of *Cacops* in any essential respect. The vertebra connected with the first dorsal spinous expansion has the proximal end of the ribs attached. It is broad and flat, articulating with the transverse process and hypocentrum like the early ribs of *Cacops.* The ribs evidently had no uncinate projections like those of *Aspidosaurus* or *Euchirosaurus.* The under surface of the more posterior expansions is shown characteristically in Broili's figure (*Paleontographica,* LI, Pl. V, Fig. 5*b*).

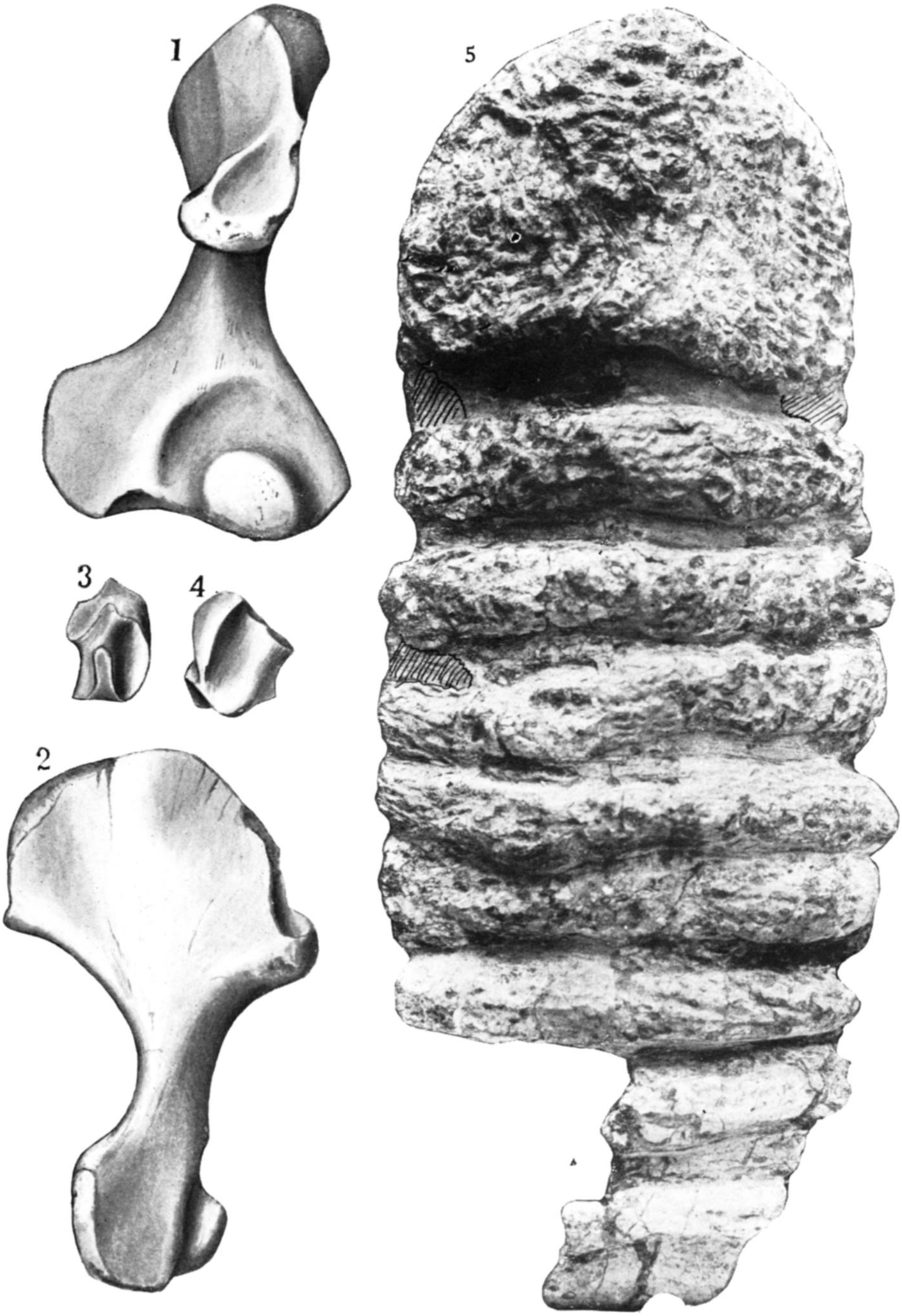
Scapula.—The scapula of *Dissorophus* differs markedly from that of *Cacops* in its greater robustness and in its more upright position. The posterior border is thickened and has a more pronounced convexity near its middle. The preglenoid facet is very prominent as a sharp ridge, immediately below which is the opening of the infraglenoid or supracoracoid canal and, close by, back of the lower part of the same facet, is the opening of the glenoid canal. The ridge continuous with the preglenoid facet is less prominent than in *Cacops;* the post-glenoid part, or metacoracoid, is more extensive, the concavity between it and the hind border of the shaft is deeper. On the inner side the deep fossa into which opens the supraglenoid and infraglenoid canals is deeper and shorter, and the epicoracoid portion is much broader below and internally to this fossa. The opening for the glenoid canal on the inner side, as in *Cacops* and *Trematops*, is opposite the lower part of the fossa.

The three glenoid foramina or canals, which I have called the supraglenoid, glenoid, and infraglenoid, appear to be characteristic of the rhachitomous amphibians, if not of the temnospondyles. I have

no knowledge of the occurrence of all three in other vertebrates. In *Labidosaurus* the scapula-coracoid, which has a wonderful resemblance to these forms, has a distinct supraglenoid opening in the same position, opening internally in the same way with the inner opening of the infraglenoid foramen in a smaller fossa. So, also, in the pelycosaurs there is a corresponding foramen, though it may pierce the bone more in advance of the glenoid depression. In none of these forms, however, have I been able to distinguish a glenoid foramen; certainly there is no inner opening corresponding to that of the amphibians in any of these reptiles. In *Varanosaurus* the sutural line between the scapula and coracoid (epicoracoid or procoracoid) passes backward through the preglenoid facet, and through the place where the glenoid foramen should be, were there one. The suture for the metacoracoid (coracoid auct.) is back of this place in *Varanosaurus*. Unfortunately, in none of the amphibians have I, or others, been able to distinguish the divisional sutures between scapula and coracoid in front, or that between the scapula and coracoid and the metacoracoid behind. There can be scarcely a doubt that the extraordinary resemblance of the amphibian girdle to that of the cotylosaurs and pelycosaurs extends also to its intimate structure, and that the relations between the scapula, coracoid, and metacoracoid are identical in the two groups. The demonstration of this, however, is not yet possible. What the significance of the glenoid and supraglenoid canals is in the amphibians, the supraglenoid in the reptiles, must await further researches. The latter is present in *Iquara*.

The cleithrum or supraclavicle is a much heavier, but more slender bone in *Dissorophus* than in *Cacops*. It lies, as in that genus, loosely over the top of the scapula, not suturally united with it, arching rooflike over the top. In front it descends over the rounded superior anterior angle of the scapula, fitting into a depression of that bone. Below, it unites by a long oblique suture with the upper end of the clavicle, extending as a narrow, anteriorly curved process quite to the place where the coracoid turns inward, that is doubtless to the sutural line between scapula and coracoid.

Various views have been entertained as to the origin, nature, and fate of this bone; the one usually accepted is that of Gegenbaur, that it represents a like bone in *Polypterus;* and this seems to be altogether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probable. As to its fate, the only theory suggested is that of Gaudry, that it represents the acromial ossification of the higher vertebrates; and this too seems not unreasonable. The union between clavicle and cleithrum in *Dissorophus* is a very close, sutural one; in the early reptiles only the lower end of the cleithrum is left; the co-ossification of this with the scapula would account for the acromion, if it be not a mere epiphysial ossification. In *Eryops* the cleithrum is suturally united throughout with the scapula above, in the position of the suprascapula.

Interclavicle.—The interclavicle is a broad, gently concave, and thin bone, resembling that of *Cacops*, but larger and broader. It has a rounded, thin border anteriorly, and similarly rounded, thin lateral margins. Posteriorly the bone is broken away but the thickened median part indicates a posterior median extension, probably as in *Cacops*.

Clavicles.—The clavicles are large, broad, smooth bones, meeting each other in the middle line, and covering, for the most part, the interclavicle. They are convex below, with their greatest expansion some distance away from the middle. In the position in which the girdle now is, evidently the normal one, the cleithral ends are directed vertically upward, nearly parallel to each other, with an interval of a little more than two and a half inches between their upper extremities, which are suturally and closely united to the lower ends of the cleithra or supraclavicles. The upper extremity is much stouter and broader than is the case with *Cacops*.

Upon the whole, the pectoral girdle, both primary and secondary, is remarkable for its stoutness and firm articulations.

Humerus.—Of the two humeri, the left is preserved completely save the capitellar angle, while the right has the lower end perfect with the upper extremity wanting. In the figures the capitellar portion has been reversed from the right side. In general shape and structure the bone resembles that of *Cacops* closely, so closely that there may be difficulty in distinguishing them in ill-preserved specimens. The humerus of *Dissorophus* is distinctly stouter, with the ends a little more expanded and the lateral curvatures a little deeper; the entepicondylar expansion is stouter.

Femur—The right femur is preserved in pretty good condition

save the external condyle and a part of the lower portion of the crest. Its resemblance to the femur of *Cacops* is close, but, like the humerus, differs in its greater stoutness. The adductor crest is heavier, and not as deep, the shaft is distinctly stouter. The articular surface for the tibia is rather better defined than in any of the specimens of *Cacops* examined. The surface is flattened, or with a gentle antero-posterior convexity with sharp rims. It is broadest on the inner side, narrower in the middle, and again somewhat expanded from before back on the outer side. The surface looks backward at an angle of about forty-five degrees from the longitudinal plane of the bone, with a light obliquity inward.

A large part of the left innominate bone is preserved, enough to demonstrate its close resemblance to the corresponding element of *Cacops*. Nor do the proximal ends of the tibia and ulna differ materially; like all the other parts, they are stouter.

The relationships between *Dissorophus* and *Cacops* are very evident, so evident, indeed, that for some time I was in doubt of their generic distinction. It would seem, however, that the much greater development of the carapace in *Dissorophus* together with the presence of the very large shield, which seems to be entirely absent in *Cacops*, together with other differences in skull and pectoral girdle, is amply sufficient to separate the two forms generically. And it is also evident that these two genera, presenting the unique characters they do, are entitled to a higher rank than genera. The characters of the family Dissorophidae I have already given, as based upon *Cacops* and *Dissorophus*. Whether or not the genus *Aspidosaurus* Broili should be placed in the same family is a matter of doubt. So far as the carapace is concerned the differences seem radical, in the absence of spinous expansions of *Aspidosaurus*, the dermal shields forming a shingle-like imbrication. However, other characters, so far as the known details furnished by the type specimen of *Aspidosaurus* are concerned, seem very like those of this family, and it is possible that the family characters may have to be emended in the future to include Broili's genus.

Although the known remains of *Zatrachys* are yet very meager, it would seem certain that the genus cannot be included with *Dissorophus*, and that the family Zatrachydidae will find eventual justi-

fication. The remarkable characters of *Trematops* also justify the creation of a family for its reception, with possibly *Acheloma* as an allied genus. Of the other American genera of temnospondyles, *Eryops* has long been considered of family rank, as also *Trimerorhachis*. None of these genera, so far as my knowledge goes, possessed either dermal or ventral armature, other than the carapacial development of the Dissorophidae and Zatrachydidae. Dermal plates have been accredited to *Trimerorhachis*, but I believe wrongly, since several specimens in the Chicago collection although including almost all parts of the skeleton give not the slightest indication of such. Nor were there any dermal plates, ventral or dorsal, in either *Trematops* or *Eryops*, and I am convinced that none will be found in *Zatrachys*, when better known. That there were amphibians in the American Permian with isolated dermal scutes is, I believe, certain from the evidence furnished by the Orlando bone bed, though perhaps they were all small animals. Thevenin has discovered dermal ossifications in *Euchirosaurus*, which he believes to be identical with *Actinodon*, and, furthermore, from his figure and descriptions of the ribs in that genus, it is quite certain that its relationship with *Eryops* is not nearly so close as has been thought, and as Thevenin believes. Similarly expanded ribs are characteristic of *Aspidosaurus*, apparently. Furthermore, we have no evidence so far, among the American forms, of a long tail, unless it be in *Trimerorhachis*, which differs so much in many ways from the other temnospondyles that it may well be it had also a long tail. Thevenin gives the number of presacral vertebrae in *Euchirosaurus* as twenty-two or twenty-three, I have determined the same numbers in *Trematops*, while in *Cacops* the number is positively fixed at twenty-one. Branson[1] gives the number for *Eryops* as twenty-five or twenty-six, though he found in no specimen more than twenty-four in a continuous series. Perhaps there is some variation in the various genera, but evidently the number never greatly exceeded twenty-two. Branson speaks of a small isolated arch in the atlas; if he be correct, the atlas differs materially from those of *Trematops*, *Cacops*, and *Dissorophus*. But I believe it will be found that the *Eryops* atlas was of like structure, that is, with co-ossified neuro- and hypocentra, with the sides of two neurocentra separated above. Bran-

[1] *Journal of Geology*, VIII, 603.

son described all the presacral vertebrae of *Eryops* as having double-headed ribs, attached to diapophysis and hypocentrum, while in *Cacops* it is only the anterior vertebrae which articulate with the hypocentrum and this is also clearly the condition in *Dissorophus*.

So far these are all the described genera of rhachitomous amphibia from the American Permian. The genus *Cricotillus* Case I suspect is identical with *Crossotelos* Case, a "Microsaurian" amphibian, while *Cricotus* is an embolomerous form.

Recently Case has discovered that *Otocoelus* is identical with *Dissorophus*, as indeed the figures given by Cope indicated. Whether or not the genus *Conodectes* Cope is also a related temnospondyl it is impossible to determine without examination of the type. The description given by the author of the genus is utterly inadequate for its recognition.

Following is a taxonomic summary of the known American Permian Amphibia.

CAUDATA.
- Lysorophidae Williston, 1909 (Paterosauridae Broili, 1904).
  - Lysorophus Cope, 1877.
    - tricarinatus Cope, 1877, Illinois, Texas, Oklahoma.

"MICROSAURIA" (Diplocaulia Moodie).
- Diplocaulidae Cope, 1881.
  - Diplocaulus Cope, 1877.
    - salamandroides Cope, 1877, Illinois.
    - magnicornis Cope, 1882, Texas.
    - limbatus Cope, 1896, Texas.
    - Copei Broili, 1904, Texas.
    - pusillus Broili, 1904, Texas.
- Crossotelidae Williston, 1909.
  - Crossotelos Case, 1903, Oklahoma.
    - annulatus Case, 1903.
  - ? Cricotillus Case, 1903, Oklahoma.
    - brachydens Case, 1903.

TEMNOSPONDYLI.
- Embolomeri.
  - Cricotidae Cope, 1884.
    - Cricotus Cope, 1873.
      - heteroclitus Cope, 1875, Illinois, Kansas.
      - gibsoni Cope, 1877, Illinois.
      - crassidiscus Cope, 1884, Texas.
      - hypantricus Cope, 1884, Texas.

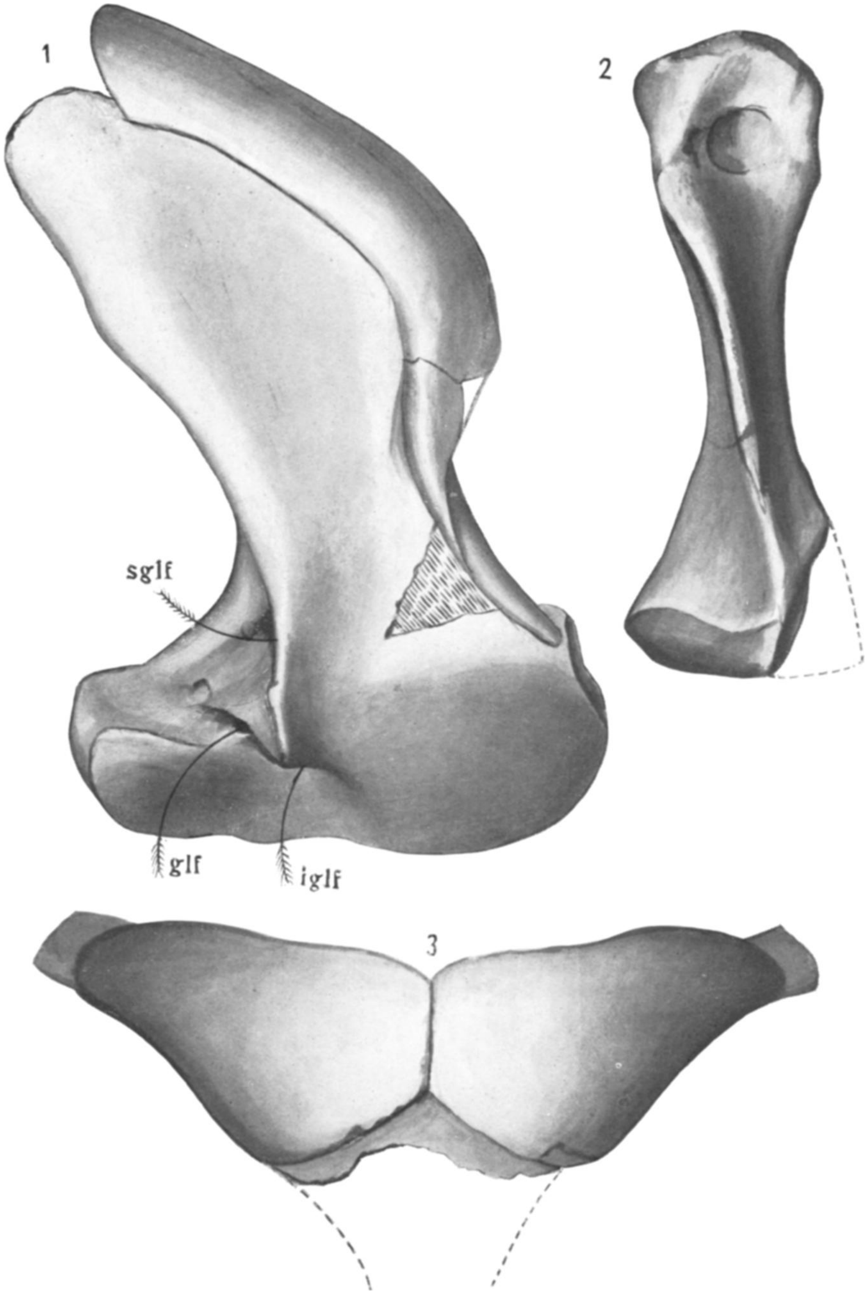
Rhachitomi.
- Eryopidae Cope, 1882.
  - Eryops Cope, 1877.
    - megacephalus Cope, 1877, Texas.
    - erythroliticus Cope, 1878, Texas.
    - ferricolus Cope, 1878, Texas.
    - reticulatus Cope, 1881, New Mexico.
    - latus Case, 1903, Texas.
  - Anisodexis Cope, 1882.
    - imbricarius Cope, 1882, Texas.
- Zatrachydidae, Nov.
  - Zatrachys Cope, 1878.
    - serratus Cope, 1878, Texas.
    - apicalis Cope, 1881, New Mexico.
    - conchigerus Cope, 1896, Texas.
    - microphthalmus Cope, 1896, Texas.
- Trematopsidae Williston, 1910.
  - Trematops Williston, 1909.
    - milleri Williston, 1909, Texas.
  - ? Acheloma Cope, 1882.
    - cumminsi Cope, 1882, Texas.
- Dissorophidae Williston, 1910. (Otocoelidae Cope.)
  - Dissorophus Cope, 1895.
    - multicinctus Cope (? articulatus Cope), Texas.
  - Cacops Williston, 1910.
    - aspidephorus Williston, 1910, Texas.
  - ? Aspidosaurus Broili, 1904.
    - chiton Broili, 1904, Texas.
- Trimerorhachidae Cope, 1891.
  - Trimerorhachis Cope, 1878.
    - insignis Cope, 1878, Texas.
    - bilobatus Cope, 1883, Texas.
    - conangulus Cope, 1896, Texas.
    - mesops Cope, 1896, Texas.
    - leptorhynchus Case, 1903, Oklahoma.
- Incertae sedis.
  - Cardiacephalus Broili, 1904.
    - sternbergi Broili, 1904, Texas.

EXPLANATION OF PLATES

PLATE I.—*Dissorophus multicinctus* Cope; dorsal view of skull. Three-fourths natural size.

Plate II.—*Dissorophus multicinctus* Cope. 1, left humerus from in front; 2, the same from inner side; 3, 4, proximal carpal bones; 5, dorsal view of carapace. All figures natural size.

Plate III.—*Dissorophus multicinctus* Cope. 1, right scapula-coracoid, with attached cleithrum, from outer side; 2, right femur, from behind; 3, clavicular arch, from below. All f gures natural size.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sglf
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